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MARKET RESPONSE MODELS FOR THE ANALYSIS OF NEW PRODUCTS*

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ABSTRACT

This paper reviews mathematical market response models in the context of their behavioral relevance and ease of testing, estimation, and solution in the analysis of new products. A new type of model called a "macro behavioral process" model is proposed as a method of obtaining high behavioral content while maintaining the simplicity necessary for evaluating many marketing strategies.

INTRODUCTION

New product decisions have been receiving increasing attention from model builders. Models have been developed to aid in the search for new ideas,[1] the screening of alternate proposals,[2] the analysis of proposals,[3] and the market implementation of new products.[4] This paper will concern itself with the analysis stage of the decision process where an attempt is made to identify the best marketing, production, and financial strategy for the project. The profit, sales, and market share generated by this best strategy are then compared to the risk and investment to make a GO, ON, or NO decision for the product. Underlying this decision, there must be a market response model. The purpose of this paper is to review the existing response models in the new product area and then to propose a new modeling construct for use in new product decisions.

New Product Market Response Models

A number of alternate market response models could be used in analyzing the strategy for a new product. These models represent varying levels of detail. For example, a simple breakeven analysis reflects a low degree of detail while a micro-analytic simulation represents a high degree of detail.[5] Between these extremes are single variable and multivariable macro models. These may be single equation or multi-equation models. The question to be considered is, what level of detail should be used in building an analysis model?

In order to answer this question, the various levels of detail will be considered in terms of their ability to capture the behavioral

phenomena underlying the diffusion of new product innovations and their ease of testing, estimation, and solution.

First, consider a one variable, single equation model that links sales to advertising.[6] This model would be relatively easy to solve by calculus. It would also be relatively easy to test and estimate since it involves only one variable. It would be limited, however, in considering the behavioral process underlying the purchase of a new product since it considers the aggregate response to advertising and does not explicitly include consumer behavioral phenomena. The next level of detail would be a multi-variable, single equation model.[7] This form is richer in behavioral content since it includes marketing mix effects and can comprehend the behavioral processes of diffusion, marketing mix, and product interdependency at an aggregate level. This type of model is more difficult to test for validity and sensitivity. It is also more difficult to solve and usually iterative routines must be utilized.

Just beyond the multi-variate, single equation model, in terms of level of detail, is the multi-variate, multi-equation model.[8] This type of model can begin to comprehend the basic process by forming a causal chain. For example, DEMON uses a causal chain of advertising to exposure (reach and frequency), to awareness, to trial (also dependent on distribution and promotion), to usage rate, and total demand (as a function of price). The potential of this level of model detail has been penetrated, but it could be improved by including consideration of competitive, carryover, product interdependency, and diffusion effects. Multi-equation models may encompass more behavioral phenomena than single

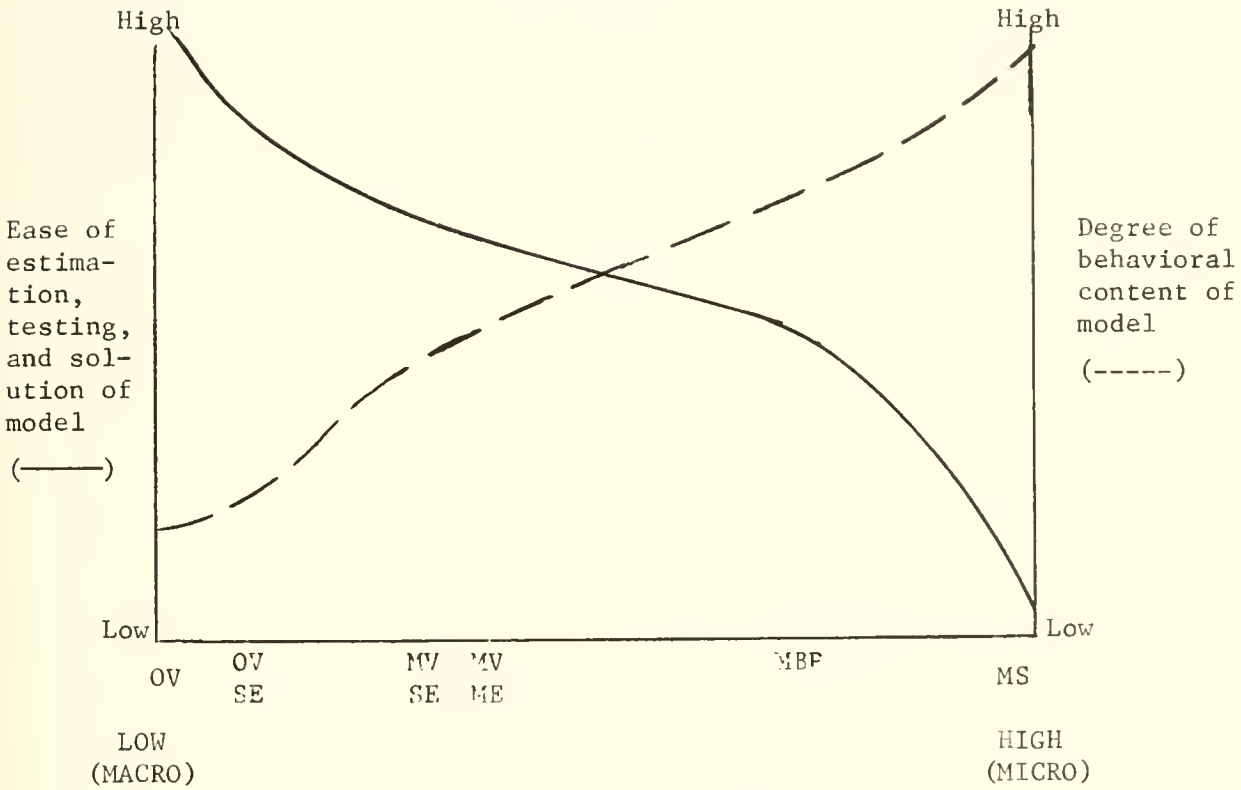
equation models but they are also more difficult to estimate,[9] test, and solve.

The level of detail represented by the macro models discussed in the previous paragraphs is much lower than the micro-analytic simulation approach.[10] A micro simulation model may contain 1000 separate market units and each unit can carry on a very detailed behavioral process. The level of detail in comprehending the consumption process is extremely high. Customers begin by developing a perceived need based on previous use experience and attitudes toward the product, advertising appeals, and brand. The controllable variables underlying this perceived need are advertising and product design. If perceived need is strong enough, the consumer makes a decision to shop based on his attitude towards retailers and income. If a shopping effort is made, the decision to purchase is dependent upon the availability in the particular store, absolute and relative prices, the amount and intensity of effort and the attitude towards the product. Forgetting, word of mouth generation, and an update of attitudes occur after purchase. This behavioral process is considered in meticulous detail and represents a high level of behavioral content. The difficulty in estimating and testing the model is very high. There may be many thousands of parameters to estimate and hundreds of functions to validate. In addition, the running time of such a model is so high that only one or a few alternative strategies can be evaluated. This does not generally solve the multi-variate, multi-period, strategy problem faced in the analysis stage of new product development.

The graphical interpretation of the remarks in the previous paragraphs appears in Figure 1. As the level of detail increases, the behavioral content increases with a rapid increase at the micro level. The ease of testing, estimation and solution decreases as the level of detail increases and drops sharply at the micro level. To determine the best level of modeling, the decision problem and the constraints on the modeling must be considered. If the firm has few resources and little time, the model would be constrained to low level of detail. If the firm had a large budget and no time or personnel constraints, the model could assume any level. In this case, the desired level of problem solving detail would dictate the best modeling level. In the new product case this would argue for a more micro model since it is desirable to include the behavioral content of the adoption process and the problem would require detailed output. In most new product cases, the budget and time constraints will preclude a micro-analytic simulation, but would justify a model with a reasonably high level of detail if it could generate solutions to the marketing mix problem and lend itself to testing and estimation. Such a model would fall near point MBP in Figure 1. This might be called a "macro behavioral process" model. This model could have a high level of behavioral content, but be feasible to develop and operate on a limited budget. The remainder of this paper will outline the structure of such a macro behavioral process model for use in new product analysis.

FIGURE 1

MODEL DETAIL VERSUS BEHAVIORAL CONTENT
AND EASE OF DEVELOPMENT



OV = one variable
MV = multivariate
SE = single equation
ME = multiple equation
MS = micro-analytic simulation
MBP = macro behavioral process

MACRO PROCESS MODEL: AN EXAMPLE

In order to demonstrate the potential of the macro behavioral process level of detail, an example of this model structure will be presented for a new frequently purchased consumer product. First, the behavioral content and market phenomena that are most relevant are specified on an a priori basis. Then after a set of model development criterion are outlined, the model structure is presented.

Essential Behavioral and Market Phenomena

The most basic behavioral phenomenon associated with new products is the diffusion of innovation process. The time of first purchase of the product, the flow of communication, and the sales growth pattern of the product are important to new product decisions.

Rogers and Stanfield have identified a number of emerging generalizations in this area.[11] They describe a set of characteristics of innovators such as education, attitude towards change, cosmopoliteness, deviancy from norms, and exposure to interpersonal communications. These characteristics condition the structure of any new product model, but of more particular interest are the properties of the innovation that encourage early adoption. The most significant factors identified by Rogers and Stanfield are relative advantage, compatability, and fulfillment of felt needs. These factors can be influenced by new product design, the product's price, and its communication strategy in terms of the appeals, media, and budget. The compatability of the product to the adoptor will depend in part upon his perception of the social

and psychological risks associated with the product.[12] Advertising may help in reducing this percieved risk of trial. It also plays a role in reducing the cognitive dissonance that may develop after the innovation has been tried and product use experience has been collected. The post purchase processes of selective perception, selective forgetting, and word of mouth communication that are associated with cognitive dissonance are important to recognize in examining the new product diffusion process.

Pessemier, Burger and Tigert have empirically identified some diffusion phenomena.[13] They found that innovators could be identified, that they were active in more word of mouth transmission than non-innovators, and that they tended to be more trial prone than later adopters. The word of mouth communication flow between opinion leaders and other small group members appears to be an important phenomena in the diffusion process. The change of the trial proneness over the duffusion process is consistent with the diffusion structure that classifies consumers as innovators, early adopters, early majority, late majority, or laggards on the basis of their time of adoption. This classification would imply a non-stationarity to market response.

A new product model which is designed to have a high level of behavioral content should be able to embrace the behavioral diffusion phenomena outlined in the last two paragraphs. In addition to the diffusion process, the basic consumption process must be considered.[14] The development of awareness, attitudes, and preference must be specified. These should then be linked to higher functions such as the intent to

purchase and shop and finally to brand choice. After purchase, the behavioral processes of forgetting and interpersonal communication should be considered.

Consumers will move through this decision process, but the way in which they respond at each stage will be heterogeneous. It could be expected that trial behavior will be different from repeat purchase behavior. The process a consumer experiences between trial and loyalty or non-loyalty should be an explicit part of the model. This heterogeneity due to depth of class purchase effects may also be different in certain subsegments of the market. At least some consumer segmentation should be allowed in a model with acceptable behavioral content.

In addition to this minimal set of behavioral phenomena, the market phenomena of competition, product interdependency and industry sales effects should be considered. The consideration of these effects should include explicit recognition of the influence of controllable variables such as price, advertising, personal selling, channels of distribution, middlemen margins, and point of sale promotion in the consumer process.

The goal of the macro process model is to capture the essential diffusion, consumption, and market phenomena in a model that can be developed, estimated, and solved with a reasonable commitment of resources. This model development criterion would dictate that the model be as parsimonious as possible, subject to the requirement that the behavioral content described in the previous paragraphs be included.

A Behavioral Macro Process Model Structure

With the goal of achieving efficiency and behavioral content in mind, a macro process new product model will be described. This model begins by defining the steps in the consumption process, then developing these steps for several depth of class groups, and finally linking controllable variables to the process.

Behavioral Processes: The basic process elements of the model are: (1) awareness, (2) intent, (3) search, (4) selection, and (5) post purchase behavior. In the awareness model, consumers are classified on the basis of their awareness to the brand, its advertisements, specific product appeals, and to word of mouth recommendation. These classifications represent exclusive hierarchal division. That is, people who are classed as brand aware are only brand aware. People who are ad aware are brand and ad aware, but not aware of any appeals. People classed as aware of a specific appeal of the product are aware of the brand, ad, and that specific appeal, but no other appeals. The assignment of people to these classes is based on an unaided recall to a brand, ad, appeal, or a word of mouth recommendation. This scheme allows selective perception to operate since it classifies people by recall and different people are observed to recall different appeals after seeing the same ad. The distribution of people in the awareness classes reflects the effects of advertising expenditures in a given period, past advertising, product experience, and past receipt of word of mouth communication.

The intent model takes each awareness class and processes it to determine how many from each class will display preference for the

brand and intent to purchase it. The percent of people in a given awareness class who display intent to buy the product will depend upon the perceived compatability and relative advantage of the product to the people who have the specific recall of that class. It would be expected that the percent with intent would be higher in appeal recall classes since this represents more perception of relative advantage. The highest buying rates might be expected in the awareness class representing receipt of word of mouth recommendations since this group would be one in which the perceived risk is low. After the number of people intending to buy has been determined for each awareness class, they are added to get the total number of people with intent. These people now undergo a search effort in an attempt to find the product.

The search model determines if the product is available at the consumer's favored retail store. This availability is based on the percent of distribution obtained by direct company and wholesaler sales effort when given a particular middleman margin or "deal." If the brand is not available the consumer may delay choice and search at a different store.

If the product is available, the consumer with intent will choose the brand unless he is switched to another brand in the store. This switching is dependent upon the relative price and point of sales activity of the brand. Those consumers with no intent before entering the store could purchase the brand on the basis of the in store price, promotion, and communication. If they purchase, they are added to the buyers who exercised their intent. This produces the total number of buyers.

If a consumer buys a product, he may generate word of mouth recommendations or can respond to word of mouth inquiries by non-buyers. These exchanges are particular in content and receivers are moved to new awareness and appeal classes on the basis of receipt of new information and its internalization. After each period, consumers experience forgetting. They forget selectively from one appeal awareness class to another so cognitive dissonance can be considered. After the completion of these post purchase phenomena of word of mouth and forgetting, the consumers in each awareness class are returned to the awareness model for the receipt of new communication and a repeat of the consumption cycle. As the cycle is repeated, the model's parameters such as trial rate are allowed to change so that the non-stationarity of buyer response can be encompassed.

This process sounds verbally similar to a micro model, but it is macroscopic because it is always concerned with the average behavior of consumers. For example, it deals with the average intent to purchase rates from each awareness class. It is concerned with average retail store preferences and average in store choice and past purchase effects. The use of expected value results allows the aggregation necessary for efficient computer evaluation.

Depth of Class Effects: The five step behavioral process outlined in the previous paragraphs takes place in each of four submodels of the total macro behavioral process model. The sub-models represent heterogeneous purchase histories of the consumers. See Figure 2. The first is the trial model. All potential consumers of the type of

product who have not tried our brand of the product are in this model. The total number of potential buyers of this product class is influenced by the combined communication and promotion effort of the firms in the industry. Consumers exit the trial model by a purchase of our brand of the product and move to the preference model. In the preference model, the consumer develops and displays his preference by additional purchases of the brand. If the new product is purchased again, the consumer moves to the loyalty model where he either displays loyalty by a purchase and moves to the loyalty II model, or makes no purchase and returns to the preference model. To enter loyalty II, a consumer must have purchased at least three times and twice in succession. These four models allow heterogeneity due to product use that was a priori specified as relevant in the analysis of new products.

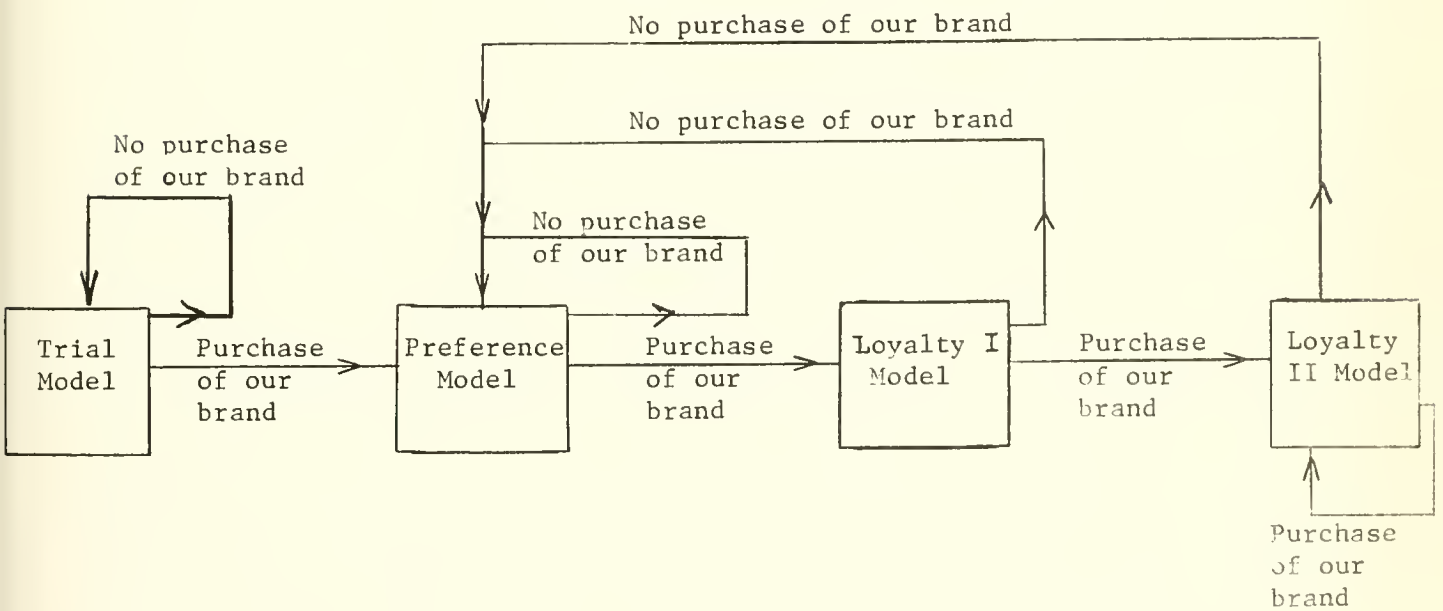


FIGURE TWO

DEPTH OF CLASS MODELS

In each of the purchase history sub-models, the buying process is considered at a different level of detail. In the trial model, each awareness class is processed to produce an intent-to-try rate, while in the preference model the awareness classes first generate rates of first and second preference. Then these rates are modified by switching probabilities based on competitive advertising to produce the number of consumers with intent to rebuy our brand. This difference in detail is justified by considering the basic process. In the trial model,awareness and appeal recall classes are translated to intent-to-try rates on the assumption that competitive advertising will not materially effect the decision to try our brand. In the perference model, it is assumed that after one purchase, competitive advertising is more important and therefore deserves a more detailed consideration through switching rates of a variable Markov process. It is the judicious choice of such aggregations that makes the macro behavioral modeling approach efficient. Naturally these aggregation assumptions must be validated empirically.

In the particular model under consideration the preference model is the most detailed. In addition to the added detail in considering competitive advertising, the preference model also includes two additional awareness classes. These are positive product use recall and negative use recall. The number of people in these classes depends upon the product performance and the level of advertising through consideration of cognitive dissonance. The trial model is not quite as detailed as the preference model and the loyalty models are even less detailed. The loyalty models assume the consumer has a source of supply for the product

and use average repeat buying rates which depend only on competitive price and promotion effects.

Effects of Variables: The mathematical statements in each model will not be developed in this paper since the purpose of this exposition is not to provide a detailed specification of the model, but rather to show the potential of the macro behavioral process level of detail in new product analysis. The specification of the behavioral process in each of the depth of class sub-models allows a process consideration of the effects of variables. For example, advertising affects the number of people in each awareness and appeal class and, therefore, through this measure of communication effectiveness influences the number of people trying and preferring the product. It also affects the switching rates from preference to intent to buy our brand in the preference model. Finally, it affects the repeat buying rate in the loyalty models.

Distribution effects are monitored by availability and "in store" effects in the trial and preference search models. The availability is related to the number of sales calls (direct and by wholesalers) on retail store types and the relative "deal" offers. The availability is also related to the sales of the product in the store through an examination of actual sales versus the middleman's expectation of sales. Since sales also depend on advertising, a marketing mix effect is produced. Price affects the relative advantage of the brand as the buyer makes the in store selection. If the price is changed, buyers may either switch to or away from the brand. The final distribution effects are the point of purchase efforts. The number of

facings and special displays are considered as a mix and consumers react to the relative effectiveness of the brand's point of purchase presentation.

The linkages of variables to the awareness, search, and choice process elements allow the model to evaluate alternate marketing strategies. This is done iteratively and on line by a computer search program which utilizes the manager as a heuristic.[15]

Alternate strategies will produce different diffusion patterns. As advertising is increased, for example, the number of people in awareness and appeal classes change, availability changes, overall trial and repeat rates increase, the amount of word of mouth communication increases and the diffusion process accelerates. Other model phenomena affect the diffusion rate. For example, as stated earlier the trial rates for each awareness class are allowed to take on different values so that the trial proneness of early buyers can be identified.[16] One final method by which the model can consider diffusion is by segmenting the market. The number of segments must be relatively small (e.g. less than five) if computational efficiency is to be maintained, but this will allow basic classes of innovators to be considered separately.[17]

Estimating, Testing, and Solving a Macro Behavioral Process Model

It should be clear that the macro-process model when structured by relying on the basic behavioral phenomena can achieve explicit consideration of the basic diffusion and consumption process. The second goal the model must satisfy is that input can be generated, that it can be tested, and that it can yield solutions with a reasonable commitment of resources.

The number of input values required in a macro-process model is large. For example, the number of people who will fall into awareness and recall classes must be specified for various levels of advertising. Then the percent of each class that intends to try the product must be identified. Some of the input may be obtained from the test market data. For example, if awareness and recall had been monitored by a continuing sample of people during test marketing, this data could generate estimates of the trial rates and composition of awareness classes for one advertising level. The estimate of the effects of other advertising levels might be obtained from an experimental design, but usually this is not available. If there is no empirical data, subjective judgments by managers must be used. The basic input philosophy is to use the full potential of the empirical data base, but then allow this to be supplemented and updated by managerial judgments. If a particular input is difficult for a manager to estimate, it could be removed from the model. However, a more sound approach would be to re-run the model for a wide range of estimates on the parameter to see if it is sensitive. If it is sensitive and no information is available, it would be wise to expend some market research funds to get information on the parameter. Then with this information, best estimates would be made, confidence intervals would be set, and the estimation uncertainty effects would be imputed in the final results by Monte Carlo analysis.[18] The model results will be dependent on the quality of the input, but perfect information is not usually required to improve the existing decision procedures.

The input problem can be best solved by integrating the model into an information system containing a data bank, statistical capabilities, and an input/output facility. The manager then accesses this system to request statistical estimates based on the test data. This data may then be reviewed and perhaps updated before being specified as input for the model. For example, in an actual application of this model a data base consisting of (1) continuing awareness, usage and recall data, (2) continuing retail store audits, (3) sales call reports, and (4) shipment records were available to support the model input requirements. Statistical regression and on-line, non-linear estimation procedures were used to obtain the model input.[19] These were then reviewed, supplimented, and updated by managers to obtain a set of input that represented the best assessment of the new product environment and behavior.

To solve the model, many alternate strategies must be evaluated. These alternatives are prescribed by managers through a remote console of a time shared computer system. After evaluating one set, other permutations can be tried until the most profitable strategy is obtained. Preliminary computational experience indicates that one thousand strategies can be evaluated in forty minutes of IBM 7094 execution time. This seems tolerable and could allow the exploration of many strategies with a reasonable commitment of funds and could lead to good if not optimal marketing mix strategies if a good interactive search technique was used.[20]

The final model consideration is testing. This model is now being tested for a new product. The model parameters are being estimated from test data and national sales are being forecasted to

determine the model's descriptive adequacy. This testing also is being done on the basis of forecasting national sales, but with an updating of the input parameters on the basis of early sales results. This adaptive testing is showing good results and it appears that the model is reasonably valid. It certainly has proved to have great logical appeal and face validity to the brand managers using the model. Although the test results are not fully available, it can be stated that the model application has resulted in a substantial increase in profit due to identifying new strategy opportunities and defining how to exploit them.

On the basis of preliminary testing on an actual product it can be concluded that the model is workable in terms of input and solution, that the model is showing good validity testing results, and that it is fostering an improvement in the quality of marketing decisions.

SUMMARY

This paper has positioned the existing models of new product market response in terms of their level of detail. This analysis indicated a gap in the range from micro-analytic to multi-variate multiple equation models that could be filled by a "macro behavioral process" model. A macro behavioral process model structure for a frequently purchased consumer good was developed and its ability to encompass behavioral phenomena was demonstrated. Early testing indicates that this level of detail is a workable one in terms of input, testing, and solution. The macro process modeling approach appears to be a level of detail where a high degree of behavioral relevance and efficiency of operation can be combined to improve new product strategy determination decisions.

FOOTNOTES

[1]See [9].

[2]See [2].

[3]See [5] and [14].

[4]See [6] and [8].

[5]See [1].

[6]See [13].

[7]See [4] and [14].

[8]See [5].

[9]See discussion of the Identification Problem in [3].

[10]See [1].

[11]See [12].

[12]See [11].

[13]See [10].

[14]See [7].

[15]See [15].

[16]See [10].

[17]See [12].

[18]See [9] and [14].

[19]See [15].

[20]See [15].

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